THE WATER-ENERGY-FOOD (WEF) NEXUS AS A TOOL TO DEVELOP CLIMATE CHANGE ADAPTATION STRATEGIES:

A CASE STUDY OF THE BUFFALO RIVER CATCHMENT, SOUTH AFRICA

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Outline

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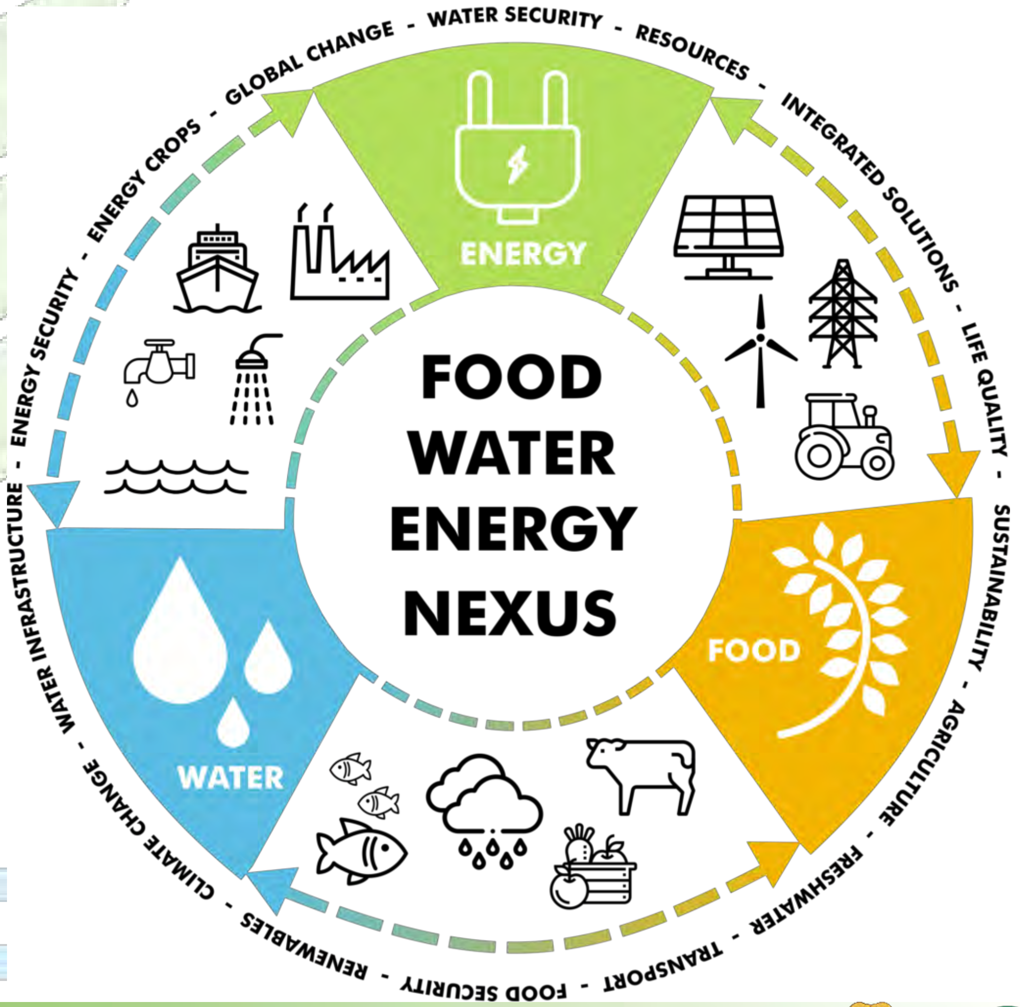
- Aim and Hypothesis
- Methodology
- Results and Discussion
- Conclusions and Recommendations

Introduction: WEF Nexus Contextualised

- Water-Energy-Food (WEF) Nexus
- Understanding interactions between the natural environment and human activities
- WEF nexus approach:
  - Conceptual framework, Analytical tools, Discourse
- Can be carried out using:
  - Conceptual visualization tools,
  - Quantitative analytical tools



Problem Statement

- Water insecurity issues in low adaptive capacity regions are influenced by:
  - Increasing temperatures
  - Fluctuating rainfall patterns
  - Inefficient hydraulic infrastructure
  - Water allocation plans
- Climatic changes and anthropogenic drivers of water availability must be considered in improving water resources management
- The Buffalo River catchment, KwaZulu-Natal, South Africa
  - Current inadequate water, problems exacerbated by the 2015/16 drought
  - Revised water allocation plans are needed to address inequities and adapt to climate change

Aim and Hypothesis

Aim:

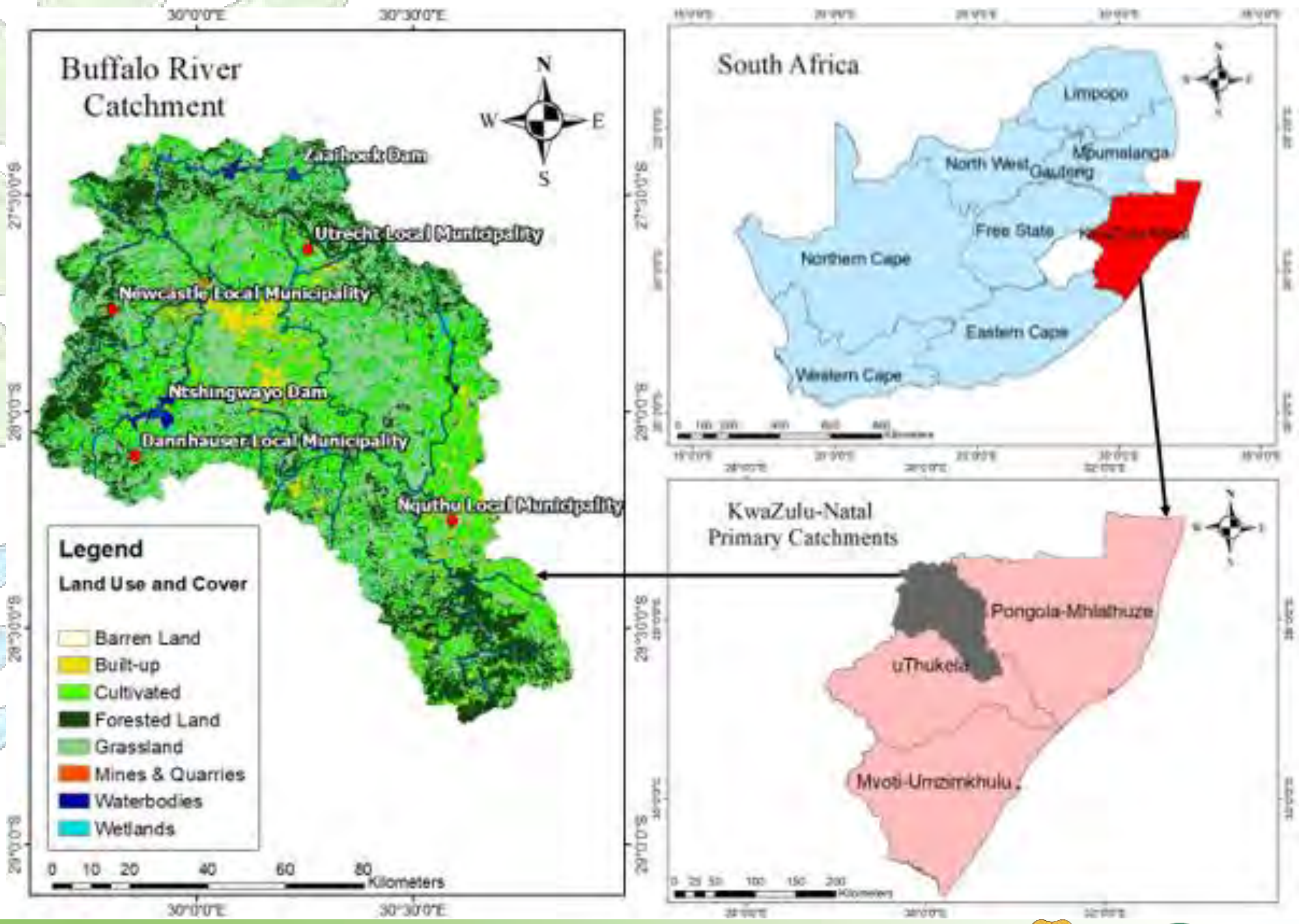
- Applying the WEF Nexus **CLEWS framework** to investigate the impacts of climate change and proposed policy interventions on a water system's reliability in supporting future demands (2019-2100).
- Case study: The Buffalo River catchment, KwaZulu-Natal, South Africa
  - Current inadequate water infrastructure causes increased water supply shortages, high underutilized agricultural potential and increased reliance on rainfed agriculture.
  - These issues were exacerbated by the 2015-2016 drought
  - Revised water allocation plans are needed to address inequities and adapt to climate change

Null Hypothesis:

- CLEWS framework will not aid in investigating the nexus between WEF sectors.

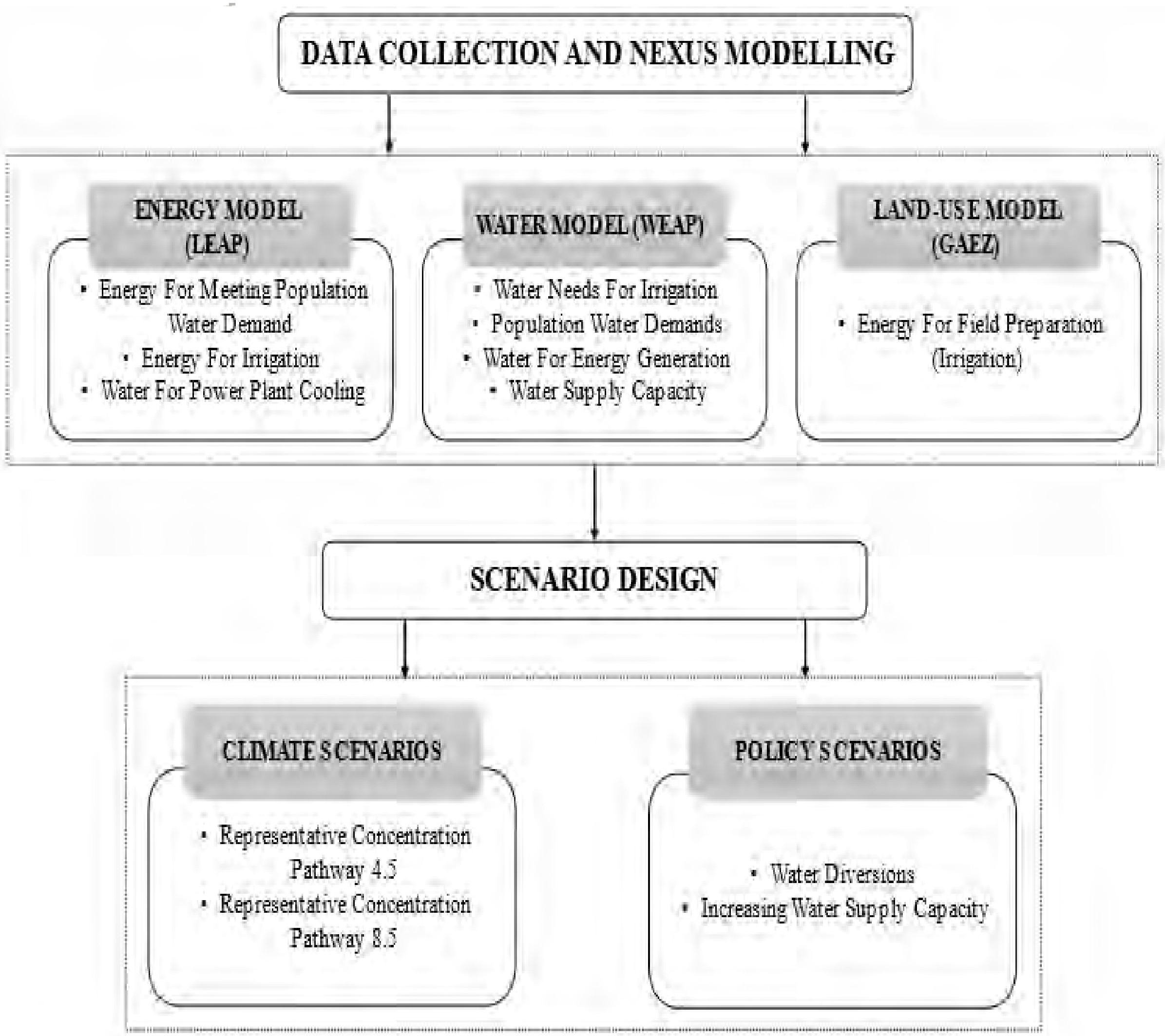
Methodology: Site Description

- *Buffalo River, Buffelsrivier* or *uMzinyathi River* catchment
- KwaZulu-Natal, South Africa
- Drainage area: 9 804 km^2
- Mean Annual Precipitation (MAP): 802 mm
- Supplies 4 local municipalities:
  - Dannhauser, Newcastle, Utrecht and Nquthu
- Total full supply capacity of surface water ~ 405 Mm^3
- Firm yield of 136.9 Mm^3/annum



Methodology: CLEWS Framework

- Interactions between **climate, land, energy, and water systems**
- Uses publicly available tools
- Study is partitioned into two phases
  - Data collection and nexus modelling
    - **LEAP**, **WEAP** and **GAEZ** models
  - Scenario design
- Study investigates 3 scenarios under climate change:
  - Business-As-Usual (BAU) (no policy changes)
  - Policy scenario (planned policy interventions)
  - Optimized policy scenario (altered policies)



Results and Discussion: BAU Scenarios

- Surface Water Store declines by 6% by 2100
  - Increased variation of rainfall and surface runoff (Dlamini et al., 2023)
- IWR decline by ~17% (RCP4.5), ~14.8% (RCP8.5)
  - Decreased land suitable for agricultural production for maize and soybean
- Energy Generation Water Requirements increase by 4%
- Domestic Water Requirements increase by **~46%**
- Met Demands by the system:
  - ~63% demands met for domestic sector
  - ~67% demands met for energy sector
  - **~33% demands met for IWR**

Results and Discussion: Policy Scenarios

- IWR, Energy Generation and Domestic Water Requirements same as BAU scenario
- Met Demands by the system:
  - ~66% demands met for domestic sector
  - ~70% demands met for energy sector
  - **~36% demands met for IWR**
- Surface Water Store reduces by ~9% by 2100
  - Unexpected outcomes, due to increased water extractions by new policies

Results and Discussion: Optimized Policy Scenarios

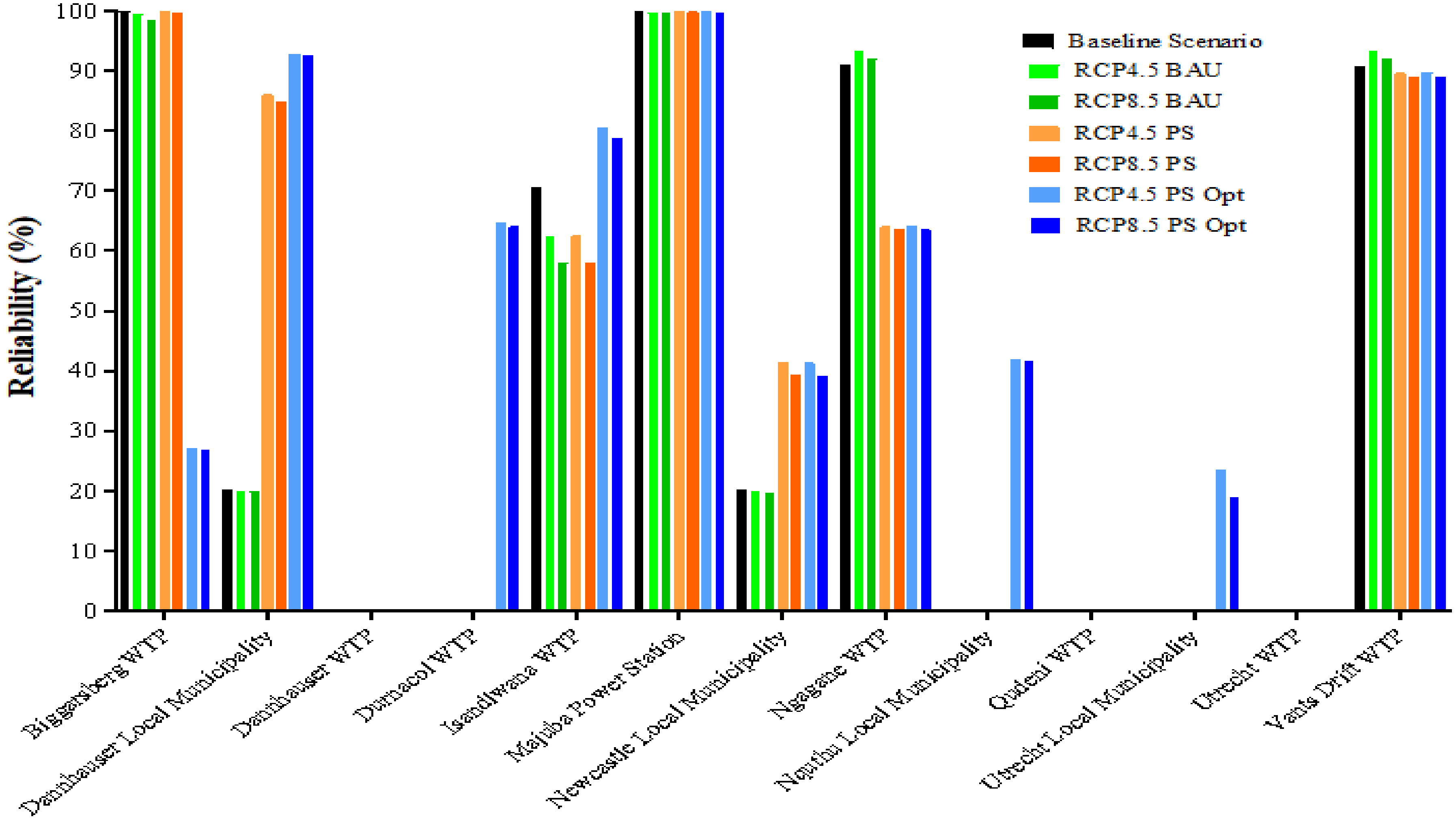
Timelines	Water Supply Strategies
Short- to Medium-Term Strategies (2020-2050)	Upgrade Ngagane WTP to deliver an extra 30 Ml/day
	Increase water abstractions from Dorps Dam to Utrecht WTP from 2 Ml/day to 4 Ml/day.
	Increase water allocations from Utrecht WTP to Utrecht local municipality from 2 Ml/day to 4 Ml/day.
	Newcastle to receive 33 Ml/day.
	Increase Biggarsberg operational capacity to 29.6 Ml/day from, 16 Ml/day, and water abstractions from Buffalo River to 25 Ml/day from 13 Ml/day.
	Decommission Dannhauser and *increase the operational capacity of Durnacol from 3.5 Ml/day to 5.5 Ml/day.*
	Increase allocation from Ngagane WTP to Utrecht local municipality to 20 Ml/day (by 2045)
	Decommission supply from Ngagane WTP to Dannhauser local municipality
Long-Term Strategies (>2050)	Construction of Ncandu Dam with storage capacity = 19.15 million m^3 and yield = 5.04 million m^3
	Construction of Ngxobongo Dam with storage capacity = 27 million m^3 and yield = 19.50 million m^3
	Increase allocation from Ngagane WTP to Utrecht local municipality by an additional 10 Ml/day, making total water allocations 30 Ml/day.
	Upgrade the Ngagane WTP to deliver 220 Ml/day instead of 130 Ml/day by 2050

Results and Discussion: Optimized Policy Scenarios

- IWR, Energy Generation and Domestic Water Requirements same as BAU scenario
- Proposed Ngxobongo Dam improves long-term water supply (>2050)
  - ~90% demands met for domestic sector
  - ~97% demands met for energy sector
  - **~98% demands met for IWR**
- Surface Water Store reduces by ~6% by 2100
  - Improved water storage infrastructure and availability

Results and Discussion:

Optimized Policy Scenarios



Conclusions and Recommendations (1)

- Reject null hypothesis: The WEF nexus CLEWS modelling framework aided in exploring the interactions between Water, Energy and Food systems
- Findings:
  - Water is unevenly distributed in the catchment
  - Agricultural potential reduced by climate change
  - Energy generation to increase due to domestic demands
  - Focus of current water policy plans is on energy and domestic sectors
  - For domestic sector, densely populated municipalities are high priority, while **agriculture-intensive regions are low priority**

Conclusions and Recommendations (2)

- Recommendations:
  - The developed optimized strategies increased surface water storage, shifted water allocations and expanded infrastructure to meet low-priority regions
    - Improves agricultural production (water-food nexus)
  - Policymakers are advised to consider developed water management strategies in planning
  - Feasibility studies are recommended
  - Use of CMIP6 climate change scenarios
  - Inclusion of other water balance components (e.g., groundwater)


thank you!